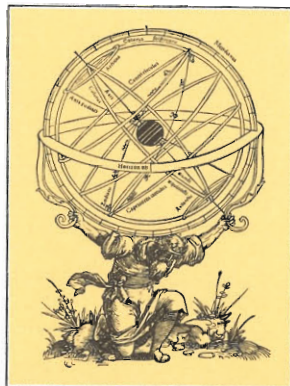


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## INTRODUCTION.

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THE following Essay was written in the fall of 1864. It is so curious a circumstance, that by an accident as a foundation, such results should flow, that the writer is loth to permit the matter to pass away without record—more especially as its truth has been in some important particulars corroborated by investigations and demonstrations, of which he was entirely ignorant, the treatise itself containing, by statement, the entire ground-work on which the superstructure is raised. The writer at that time knew nothing of the discoveries of Mayer, nor of the discoveries and theories of Count Rumford, afterwards so thoroughly demonstrated by Tyndal, nor of the writings of Helmholtz, Grove and others, as contained in a work called "*The Conservation and Correlation of Forces*." This work he first saw and obtained in the winter of 1865-'66.

The writer lays no claim to scientific ability founded on knowledge of details in matters of science; and therefore, if the results of the line of thought and reasoning set forth should by chance *point* to a great natural truth, he could lay no possible claim to any merit for it as a discovery. For the exceeding great beauty of the theory and its results, and for its sake alone, it seems worth the recording.

INTRODUCTION  
ESSAY.

ESSAY.

There may be a time conceived when Deity issued to the Universe the decree to be. It may be conceived that there was mirrored in Deity the *images* of the substance, motion necessary and change to take place thereafter, into extremest details of all things to be to the end of time; and that the carrying his order into fulfillment and completion was to be but the reproduction of these images.

Before the morning stars sang together this law of reproduction had been in action preparing them as the crown jewels of material creation. Material, motion, and the law of change governing them, became the economy of nature; and its whole history was to be accomplished by never ending change, based upon ever variegated arrangement of its own substance, producing ever variegated conditions. The spring of motion, like that of life, will never be known, but steps connected with obedience to the general law of reproduction may be.

It is supposed by what is called the nebulous theory, that at a time appointed portions of matter of a vast whole, then in a condition so greatly expanded as to be a vapor, were thrown off into space: that by the rushing of their particles inwardly a revolving motion to the different portions was given: and, that from this period the off-shoots from the parent stock commenced the course of their special lives. A second stage of these masses was marked, as is supposed, by enormous contraction of their substance. That of the earth is to be measured by the distance of the moon from its surface, on a radius taken from its centre.

The interior of the earth supposed to be fluid, would indicate the primeval condition of the elements there, modified by the feature of the enormous contraction producing increased density of its mass. There doubtless, these elements are in a condition of ceaseless movement, for what future purpose is unknown—when

ther to suffer a further contraction or to remain forever in the same state of perturbation. Upon its exterior few of the elements of its structure are found as simples, the great and almost entire bulk of them being compound in their character; affording evidence of a vast work of preparation. These elements may be said to have fulfilled some task heretofore imposed upon them by such enormous expansion, and to have been released to a state of comparative rest from their first labors, after the accomplishment of combining, disintegrating and reforming.

Heat is presumed to be the only substance which acting between the atoms of such bodies as are called simple, will widen the spaces of minimum locality of their particles to each other. Iron, for instance, is expanded in every direction by it, and settles to its maximum of density by its most complete absence. It is supposed that degrees of heat might be imparted to the elements so widely separating them as to their atoms, that in their volume they could be considered a gas still held in obedience to their special attractive force as characterized from that great one called gravity; and it is concluded that in their original state before the contraction mentioned, heat was the agent employed to give to them this gaseous form: consequently, that their contraction to present limits has been due to a radiation of heat—or in other words, to a process of cooling. It is further supposed that the interior of the earth still retains a portion of this original condition, and now possesses a heat extreme beyond our experience. There are so many evidences of this condition of the interior mass of the earth, that it is esteemed one of the settled facts of existing phenomena. But this being granted, it may be asked whether heat may not be but a mask covering the real efficient agent?

It is supposed the earth contracted to its present dimensions by a process of cooling—the heat of its state of incandescence passing or radiating off into space. But space holds no conductor of heat nor substance to receive it, and the atmosphere of the earth bordering upon space is known to be in a condition of intense cold. The theory that heat is but an evidence and condition of molecular or atomic motion, is becoming latterly, in the opinions of many, withdrawn from the class of theories into the list of facts, and

were it so proved to be, it would give rise to most important results. For, while the phenomenon and effect of heat would remain the same, the operation of a higher law effecting the results attributed to heat, and of which heat might be only an attending condition, might go towards a grouping of many apparently antagonistic phenomena under itself, so as to exhibit, if one may say so, harmonious order.

The idea of heat radiating off into space would carry with it that of a receptive power of space to contain it; and to the question, why the portions of space beyond the earth do not evince to us that they do contain it, it might be answered that it becomes so finely disseminated as to be imperceptible. But to this we have the fact that the sun is pouring forth into space near us sufficient to make the environs of our earth exhibit it, and, judging from the action of the sun near the earth, there should be accumulation. The upper regions of the air even at moderate heights exhibits so small an accumulation of stores of heat as to cause a doubt whether after all heat is other than a manifestation of a power whose exercise does not extend far from gross material in its exhibition. The sun's rays are as powerful to manifest heat at a distance of five miles of altitude as at the earth's surface, and with a sun glass an inflammable substance can be as readily fired at the one point as the other. It seems then that for its manifestation heat requires something positive or material as a base. On widely extended rolling plains, in the summer heats, one may see against the horizon a curious dancing and mazy motion in the air extending upwards from the surface of the earth until lost. It is a peculiar motion attending upon the manifestation of heat; and it will always be found that this motion accompanies heat, and requires gross material on which it may be based. Water heated in a vessel exhibits heat upon its upper portions first. Shortly after the application of heat, movement may be detected in the mass, which increasing, at last comes to a very turbulent action that we call boiling. If we dismiss the idea of heat, we have a constantly increased motion, which at last rapidly, so to speak, disintegrates the water, causing it to assume as to its structure, another form. At the first, heat accumulates in the mass of water from the top downwards. The cause of this is said to be that the heat passing

upwards finds no body to which it can be so rapidly imparted as to the water, and that as a result, there is a compelled accumulation to a point where it must force further room for its development, which it does by expanding the water to a bulk required for its accommodation. Accompanying the phenomenon, the like may be said to take place as regards motion, it increasing to a violent state of ebullition of the water, where it remains the same, relieved by the expansion of material acted on to another form.

Does the heat cause the motion, or does the motion cause the heat? Pieces of wood by hard rubbing can be made to produce fire. In this instance it is apparent that the heat manifested is the result of the rubbing called friction. Two pieces of ice may be rubbed together and an increased temperature will be the result. If the result is water, it will be found that it will indicate a greater amount of heat contained than the ice could. It has been ascertained that the revolving of a paddle wheel in cold water will raise the temperature. In all these cases it is evident that the manifestation of heat is produced by motion artificially or mechanically applied. A given quantity of water can be decomposed into its elements of oxygen and hydrogen gas, and these, by burning the latter in the former, can be resolved back into the exact quantity of water. If the gases are reduced to a lower temperature than the water from which they were derived, and a spark containing but a trace of heat produce the combustion necessary, the product will be water possessed of its latent heat; and besides this an extraordinary quantity of surplus heat will have been eliminated. In this experiment that rubbing or friction which was produced artificially in the other experiments is produced by the motion of the atoms of the gases coming together in chemical combination, and the spark of fire has only served to impart the action of combination, which like leaven extends to the whole mass, and is indicated by heat.

If heat be but a condition resulting from an atomic movement of bodies, the contraction of the earth would be due to a cessation of movement, heat ceasing with proportionate step. Judging from what we know, that with decrease of specific gravity there comes a decrease of that peculiar molecular action which produces

manifestations of heat; a theory might be formed that cessation of movement of atoms took place soonest in the substances of least specific gravity, and, consequently, would continue longer in those denser, and thus, while the entire substance of the earth settled by degrees to a state of comparative rest, indicated by the enormous contraction mentioned, the interior still is agitated by a measure of the original motion indicated by the manifestations of what we call internal heat. By this theory, if true, while all the phenomena of cooling, as it is called, would take place, the condition of the interior of the earth would not be owing to remaining primeval heat, but rather to a peculiar continued atomic motion of its particles. Latent heat would become but the index of atomic motion.

While thus the laws of heat and cold would become subordinated to one of a more extended generalization, motion and rest, it is possible that the great law of gravity itself would have to sustain a lesser classification on a like principle. The law of gravity certainly exists as does that of heat, and it would be but foolishness to disturb an idea of its being positive in its character; but there is nothing militating against tracing it back to a point where, for aught we know, there was as yet no need of its acting as a predominating agent, or to its being a condition to a law of higher generalization as heat seems to be of atomic motion. It is evident there is an intimate relation between heat and gravity, the one acting as a counter or antagonist to the other. Let it be conceived that heat be applied and confined to a particle of water at the extremest depths of the sea, the result would be that that particle of water would rise towards the surface. This would be occasioned not because of its expansion alone, because if to the expanded particle could be attributed its relative specific gravity, it would only enlarge its space among other particles; but because of its expansion depriving it of weight, its specific gravity or attraction to the earth's centre is lessened, and it tends to a contrary direction. Thus heat, and expansion, and relative loss of weight, may be considered as equivalent terms. The fact that heat has this effect is proof as positive of its power producing contrary effects to that of gravity, as the fall of the apple proves the power of gravity itself. As these two laws are the opposites

of each other, and as that of heat is probably but a condition indicating atomic movement, is not gravity but a condition indicated by the modified absence of the same thing?

"It is remarkable of physical laws," says the author of the *Vestiges*, "that we see them operating on every kind of scale as to magnitude, with the same regularity and perseverance. The tear that falls from childhood's cheek is globular through the efficacy of that same law of mutual attraction of particles which make the sun and planets round." The most perfect obedience to the law of gravity may be considered to be that state of bodies where they will not only render obedience in their aggregate mass, but also in the atomic arrangement of their particles. Water obeys the law in both particulars, ice in but one. Melted iron obeys in both: in its state of greatest density it obeys in but one. It follows, that if the whole earth were in a state of incandescence, there would be no departure from a perfect circle upon its circumference, nor from a perfect sphere as to its mass, if the effect of its rotation upon its axis is left out of view. And if the material of the earth were widely separated as to its atoms, to a tenuity as fine as the primeval elements, to hold good so far as we can comprehend it, the same result would follow. Contemplating it to exist in its character of a predominating positive law, it cannot be imagined that any atom of matter could escape from the power of gravity, save by obedience to some power acting in opposition to it. Following the idea to the nebulous condition of our planetary system, judging from the present obedience to the attractive force of a common centre, there would exist a most perfect conformity to the law, and there would be a mass aggregated into as perfect a circular circumference and as perfect a sphere as to its mass, as its motion upon its own axis would admit. But here, where might be supposed to be the condition of most perfect obedience, the predominance of the grand law seems to have failed, as it is supposed the mass had the shape of a disc, or of an extremely oblate spheroid, and we have evidence of its absence as a controlling power, in the condition in which planetary nebula are now seen to exist, having great irregularity of shape. Nor do these constitute the only reasons for supposing such a failure. Following the received idea of our

planetary construction, the parent body in its rotation (occasioned by the rushing of particles to arrange themselves towards a common centre,—a lesser feature of the controlling power of the law) threw off fragments into space. Now the law of projection must continue, or cease by the law of gravity, and if the latter, then, by reason of its ever continued force, the fragment would be brought back. How far would a deflection to a motion around the parent body affect the case? It is established that two forces tending to project bodies in different lines, act independently of each other, each acting as if the other did not exist. The deflection must be occasioned by a new power, and to effect its completion the power of tangential projection must cease. This could only be accomplished by the power of gravity, which in its turn would have to suffer a modification to preserve the circular motion given. Nor will a third theory answer, that a rim of nebulous matter was cooled to a condition that the internal mass shrank from it, leaving it arched as it were against the power of attraction. For the moment the rim should break the condition of resistance would cease. The theory of the rim consolidating by attraction to a nucleus within itself would seem still more fallacious, when it is considered that the distance from a point of breakage to the parent body would be much less than to the supposed nucleus. It is not at all intended to deny the nebulous theory of planetary formation, but only to show that we have not laws which will perfectly account for the phenomenon of construction.

Newton calculating the increased velocity of a falling body, and applying formula obtained to the movement of the earth and planets around the sun, found it to answer accurately to the times of their revolutions. But while by his formula the results of planetary movements can be exactly ascertained with reference to times of revolution; yet the force of gravity which he ascertained exactly cannot be made to account for certain phenomena of planetary motion necessary to the completion of their revolutions. The orbit of the earth being in shape that of an ellipse, its movement to accord with the law of gravity cannot be uniform, but must be of greater and less velocities according to the position it occupies in its orbit. From a diagram of the earth's imaginary orbit taken as a very



the earth's orbit is the line of no weight where all these forces are balanced, caused by influences living in the Universe, by which each body is forced to hold a line adjusted in all its points, not to the sun alone but to the entire stellar system. Such thoughts lead one to the idea that the law of gravity is, perhaps, subordinate to one of higher generalization, and that a time did exist when it did not act with the same predominating power as it seems to now.

Now heat is the general law of *expansion* or *want of weight*, as gravity is the general law of *contraction* or *attraction*, or of *weight*, and as we see the one may be but a condition of atomic movement, we are led to a very nearly similar conclusion as to the other. But while we can gather examples illustrating the first, tending to familiarize us to the idea, the other is of so obscure a nature, or rather it is apparently so much more extended in its operations that the task is more difficult. The example of the particle of water rising, when heated, shows that relatively to other substances and other particles of water it has become lighter, or has lost weight or specific gravity. As the fall of an apple is occasioned by the law of contraction, it may be asked why does not the moon and the earth contract together as the apple and the earth?—and the different laws of attraction and expansion may be illustrated in the different conditions by which an apple does fall, and the earth's satellite does not. The reason of the first is the attraction of gravitation, or in its larger sense of *contraction*; the reason of the second may be said to be from the operation of a law opposed to that of gravity, or in its larger sense the law of *expansion* or *repulsion*. But both are manifested as conditions of motion of aggregates of atoms.

In a universal sense, the worlds of the heavens may be said to be atoms obeying in their aggregated movements a union of both laws in one, and the mind rests more satisfactorily upon some element like electricity or magnetism, having within itself the union of *positive* and *negative*, or of *attraction* and *repulsion*, of consequent *contraction* and *expansion*, combined with a *never ceasing motion*, the germ of heat and gravity, which tends to satisfy conflicting phenomena. Curiously enough, the consideration that gravity may not have been an active predominating

agent, as we are pleased to call it now, in the primeval condition of our nebulous planetary mass, would lead to the conviction that that mass existed without weight and without light, bringing the mind to an appreciation, by its own involutions of that grand sentence. "And the earth was without form "and void; and darkness *was* upon the face of the deep."

But whether the laws of heat and gravity can be subordinated to one law of a higher generalization or not, the phenomena attending the action of either would not be changed. A first condition attending the extreme expansion of the atoms of the earth would be to keep them from chemically combining with each other, and the effect of their first stages of contraction would be to draw those elementary substances having the ultimate greatest density to the centre of the mass; this process continuing until a condition of contraction had taken place, admitting such combination. It is possible to conceive of incandescent substances capable of rendering obedience to the law of gravity, both as to the earth's centre and the centres of their masses respectively, assuming positions corresponding with the layers exhibited by a section of an onion. By such a condition the extremes from the centre to the outer circumference, would exhibit regular layers or strata; but each stratum would be composed of specifically lighter material. While the strata would naturally be found ranged agreeably to their specific gravities, their volumes might be wholly unlike; of some substances the total mass might be exceedingly small, and of others great, and this irrespective of their different densities.

If, too, the great work of nature was to be conducted through the operation of changes by chemical combination of substances, it might be supposed to accord with her rules, that to the material nearest to the great field of operation would be given the principle of the greatest capacity for such combination: and as a corollary, that material placed by its density at exceeding great depths would be perhaps incapable of any but the most general combination.

Oxygen gas mechanically combined with nitrogen in the air, is chemically or as to its atoms, combined with water and the materials of the earth's crust to extreme depths. It may therefore be considered to be one of the largest constituent parts of the earth's

substance. Silica of which oxygen is a compound is the principal constituent of the rocks of a crystalline character on which the entire superstructure of the earth rests. So vast is the mass of these rocks that silica may be taken to be another substance of great volume. Then we have alumina of which oxygen is a compound, forming with silica the slates and clay earths on which vegetation rests. Then calcium, sodium and potassium, the bases of the alkaline earths and alkalis. Then carbonic acid the base of vegetable life. These, with some other gases, non-metallic substances of inferior volume and metals, of which iron enters very largely into combination with the other substances of the earth, constitute the materials through which nature was to manifest her wonderful and incomprehensible changes.

It has been stated that an inference might be drawn that as chemical combination was to be the great mean through which nature was to effect her object, the material below the field of great chemical action would or might be only susceptible of very general combinations. We have an illustration of this when we refer to the densities of the substances to which the greatest and least chemical action can be attributed; but it must be borne in mind that the consideration must be taken with reference also to volume.

SUBSTANCE.	SPECIFIC GRAVITY.	AVERAGE.
Hydrogen Gas,	0.0692	
Nitrogen Gas,	0.1727	
Oxygen Gas,	1.1025	
Carbonic Acid,	1.5290	0.7183
Potassium,	0.8650	
Sodium,	0.9720	
Alumina,	2.5000?	
Calcium,	2.5000?	
Silica,	2.6900	1.9054
Iron,	7.788	
Copper,	8.895	
Silver,	10.474	
Lead,	11.352	9.627

Here, we see by the average of densities, we not only find a grade but the ratio takes abrupt increment when we pass down to the common metals.

We might suppose that of the metals of differing densities we should find the denser in company with the lighter, but not with those lower down. By referring to different articles in 'Ure' we can find the following illustrations:—*Iron* is found with manganese, silica, alumina and magnesium. *Copper* ore prepared for melting has constituent parts of copper, iron, sulphur, with tin, arsenic, and earthy matters in some cases. *Silver* has the most usual constituents of sulphur, silver, bismuth, sulphurets of arsenic, of copper, iron, lead, zinc, with several earthy materials. *Lead* is found to contain a large per-centage of silver, as high as one fifth of the whole. The mean proportion in the argentiferous lead ore, which makes it considered practicably as an argentiferous ore because the silver may be profitably extracted, is two parts in one thousand. *Gold* is found in the pure metallic state. One ore of gold is the alloy with silver. It seems to be a definite compound containing in one hundred parts, sixty-four of gold and thirty-six of silver. The ores that generally accompany it in its veins are iron pyrites, galena, and blende. *Platinum* is found in minute quantities in the gold abounding districts. Some specimens are found to contain particles of gold.

Thus it is seen that while metals of greater specific gravity are found with, perhaps, several less dense, they may be said to bring with them but traces of those of greater density; and with the exception of lead their quantity thrown up diminishes with their increased density. As a whole the above is a striking illustration of the fact supposed. The great exception to it is as to silver and lead, which although justifying the idea, because while silver contains but little lead lead ore is exceedingly rich in silver, nevertheless is a manifest exception. Yet it may be said the exception supports the rule when it is considered that the specific gravity of these two metals is almost the same, the difference being but .878, while the difference between these two and copper upon the one side is 2.931, and gold upon the other is 7.374. If our planetary system be taken as one body, where the different strata revolve around a central mass instead of being located in order upon it, the conditions of our planet upon our supposition would be but a miniature copy of those of the great whole. For the planets, it is said, show a progressive increase of bulk

and diminution of density from the one nearest the sun to that which is most distant. With respect to the density alone, we find taking water as a measure and counting it as one, that Saturn is  $\frac{13}{32}$ , or less than half; Jupiter,  $1\frac{1}{4}$ ; Mars,  $3\frac{2}{7}$ ; Earth,  $4\frac{1}{2}$ ; Venus,  $5\frac{11}{15}$ ; Mercury,  $9\frac{9}{10}$ ; or about the weight of lead.

Thus we have reason for the assertion that the natural home for substances in the earth's structure is to be indicated by their specific gravities, and that they diminish in value for varied chemical combinations with their density. The attempt is not so much to show that the earth increases in density with increased depth, but rather to see if anything points to its being composed of denser materials towards the centre, which by reason of the nature of their structure, are only perhaps capable of very general chemical combinations. Humboldt in "Cosmos" says:—"According to the most recent experiments of Reich, the result (of the earth's density) obtained is 5.44; that is to say the mean density of the whole earth is 5.44 times greater than that of pure water. As according to the nature of the mineralogical strata constituting the dry continental part of the earth's surface, the mean density of this portion scarcely amounts to 2.7, and the density of the dry and liquid surface conjointly to scarcely 1.6, it follows that the elliptical unequally compressed layers of the interior must greatly increase in density towards the centre, either through pressure or owing to the heterogenous nature of the substances."

Nature is the standard of economy, and it may be asserted as an axiom that the earth as to its bulk, substances and their quantity and quality, *must* be composed to produce all changes necessary in harmony with most perfect economy. From this it might be inferred that there would be no necessity of its interior mass being of the same substance with its exterior, when on the surface to effect the known end of intimate commingling, chemical combinations would have to take place not of a great disturbing nature, but one involving a most minute and apparently confused mixture. While greater density would tend, perhaps, to steady the whole mass, its property would be to act more in the aggregate than detail, and be productive consequently of general effects upon the surface. The upheaval of long continued mountain

chains, would indicate a movement of the entire interior mass of a uniform nature, and the movement might tend to support the hypothesis.

The age of the world preparatory to that of organized forms may be called the chemical age, marked by two kinds of motion. A superficial one, the effect of atomic combination producing by its perturbations a mechanical mixing of substances of the earth's crust; and inward movements of greatly extended effect, serving to reproduce a condition of things on the surface by which a more thorough and intimate chemical and mechanical union might be effected by continued superficial action. Upon the surface the same age may be divided into the epochs of oxygen and water. It may be inferred that as chemical combinations ceased by the absorption of oxygen, a surplus of the latter remained, which combined with hydrogen formed water, by which latter the mechanical operation of minutely mingling substances already chemically combined would be effected. But here a singular feature presents itself. It is an opinion of general acceptance, that the primeval condition of the earth's surface was of a most rugged aspect; broken into deep fissures, contrasting with mountains of corresponding height. To make this view correspond with a further one that the next great changes of the earth are to be ascribed in a great degree to the action of water, the present amount of the visible water of the earth would hardly suffice, independently of its supposed condition of ebullition. There may be supposed to have been a constant decomposition of water by its component gases uniting with masses of different substances thrown up by the perturbations of the earth's surface, and a lessening in its volume by the deposit of substances held in quasi chemical solution, carrying with them large measures of its substance, as solidified water or water of crystallization, until its mass may have been lessened and purified for its future uses. Thus the work went on; mountain ranges were levelled, different strata made by conjoint chemical and mechanical action were super-imposed on crystal foundations, until by the decomposition of water and its deposits the dry land appeared. That which is supposed of water is known as to one of its features to have been the case with the air, which with water gave up its surplus of

carbonic acid to the great coal and limestone formations preparatory to the age of animated life.

From such considerations, may it not be taken as reasonable that the mass of the earth's substance underneath the thin field of water and of matters chemically and mechanically combined, is of uniform structure as to substances of different densities measuring on radii from its centre taken indifferently?

Some facts concerning the general features of the earth's surface may lead to generalizations of an interesting character. A careful comparative general examination of the surface of the earth, shows it to be characterized by some extraordinary features. From 50° North latitude it may be said to be a smooth rounded dome, from thence growing more rugged toward and beyond the equator. The general idea is assisted if we can imagine the earth's appearance if divested of its water envelope. The southern hemisphere would present features of great confusion, and its outlines would be torn and jagged. The general comparative aspect then would be a smooth rounded northern, and a rugged broken southern hemisphere.

Examined as to its spherical shape, there would be exhibited a want of material to complete a rounded form in the southern hemisphere; and the general rotundity being completed by water, the mind would be impressed with the idea that an undue amount of the denser matter of the earth had been aggregated at the north.

Considered superficially, the continents from points widen out to the northward, and are massed as it were close to and around the north pole; while the waters present the reverse feature their masses widening out and concentrating about the south pole.

Comparatively, it may be said that the northern hemisphere is free from volcanic action, and that such action belting around the globe on the 30th parallel of north latitude as a base of commencement, extends into and occupies the whole of the southern hemisphere, its focus or rather pole being between South Victoria Land, Sumatra and South America. Mr. Darwin in his work on volcanic islands says:—"During my investigations on the coral reefs I had occasion to consult the works of many voyagers, and "I was universally struck with the fact that with few exceptions

"the innumerable islands in the Pacific, Indian and Atlantic Oceans, were composed either of volcanic or of modern coral reefs. It would be tedious to give a long catalogue of all the volcanic islands; but the exceptions are easily enumerated. \* \* \* "It results that the vast majority of the volcanoes now in action, "stands either as islands in the sea or near its shores." From "Cosmos" the following notices of volcanic action have a value relative to the subject: "The geographical distribution of "the volcanoes which have been in a state of activity during "historical times, the great number of insular and littoral volcanic "mountains, and the occasional though ephemeral eruptions in "the bottom of the sea, early led to the belief that volcanic "activity was connected with the neighborhood of the sea." "It is a fact worthy of notice that amongst the four great "parallel chains which traverse the Asiatic continent from "east to west, the Altai, the Thian-schan, the Kuen-lun and "the Himalaya, it is not the latter chain which is nearest "to the ocean, but the two inner ranges, the Thian-schan "and the Kuen-lun, at a distance of 1600 and 720 miles from "the sea, which have fire emitting mountains." "Although "extinct volcanoes seem by no means confined to the neighborhood of the present seas, being scattered over the most inland "portions of our existing continents, yet it will appear that at "the time at which they were in an active state, the greater part "were in the neighborhood either of the sea, or of the extensive "salt or fresh water lakes, which existed at that period over much "of what is now dry land." Vol. 1, p. 243. Note by the translator from Daubeny, p. 605. He also refers to Dr. Boué's map of Europe, and Lyell's map in his "Principles of Geology," edition of 1847.

Comparatively speaking then, we may conclude the northern hemisphere to be in a composed, and the southern to be in a disturbed volcanic condition: that the volcanic action at the north was the first to subside, and that the south is still subject to it: that in the north beyond the parallel of 50° of latitude, the evidences of its action to corrugate the face of the earth have been very much obliterated, while the south still presents strong marks of its disturbing character.

Now we know that if a globe weighted irregularly upon its surface is thrown in water, the lowest point will be the nadir of its density. Upon the hypothesis of uniformity of structure, as to substances of differing densities, measuring on radii from the earth's centre taken indifferently, if we take a terrestrial globe, and looking down upon it to ascertain from its superficial area of land and water its nadir of density, we will find that all lands and their location being taken into consideration, the point will lie in Asia somewhere about  $70^{\circ}$  to  $80^{\circ}$  E. longitude, and  $70^{\circ}$  N. latitude. Examined for the zenith point for the water surface we find it located at about  $60^{\circ}$  south latitude, and about  $110^{\circ}$  west longitude. To be exact these points should lie exactly opposite each other, and constitute the poles of greatest and least density. In addition to examining a terrestrial globe, if for corroboration we take any standard school atlas and turning to the maps of the world plotted on northern and southern hemispheres draw different figures upon the lands on the northern hemisphere, we will obtain like results for the same point. Thus, on the portions of the continents of Asia, Africa and Europe, contained on the map construct a parallelogram to include as much land as possible, then calculating for the lands lying outside the figure, and for the water in the figure, we will find the centre to be in or near the Caspian Sea. Constructing a parallelogram to include as much of Asia and North America as possible, in the same way we will find its centre to lie in the Northern Ocean in latitude about  $80^{\circ}$ , east longitude  $130^{\circ}$ . Constructing an equilateral triangle on all the land exhibited in the northern hemisphere, in the same way we will find its centre to lie in Lapland somewhere about  $67^{\circ}$  of latitude, and  $30^{\circ}$  east longitude. By these centres, considering the positions of lands in the southern hemisphere, and their effect to change the grand point in Asia, and endeavoring to find this point, the degrees of  $70^{\circ}$  north latitude and  $70^{\circ}$  to  $80^{\circ}$  east longitude, will give an apparently close approximation. The opposite pole to this for water would be  $70^{\circ}$  south latitude and  $110^{\circ}$  west longitude. As some confirmation that the Caspian sea is the place desired for the portion of Asia, Africa and Europe, lying in the northern hemisphere, the following foot-note in "Cosmos" having relation to the continents of Europe, Asia and Africa, is quoted. The

language is as follows:—"On the declivity of *Ararat* which with *Caucasus* may be said to lie in the *centre of gravity* of the old "continent formed by *Europe, Asia and Africa*, the very exact "pendulum experiments of Federow give indications not of sub-"terranean cavities, but of dense volcanic masses."

It may be observed that as far north as we can go the earth presents the same general features of intimate chemical and mechanical commingling of its substance. It would, therefore, indicate as efficient and active agents there as elsewhere, and lead to the idea that at one time water was as free to act as a mechanical agent there as at any other point of the earth's surface; and consequently that during a period sufficient to prepare that portion of the surface of the earth there was no ice. As the greater aggregation of material at the north is a *general* rather than a *special* feature, it may be supposed to have been caused by a general law rather than by reason of local disturbance. As it occurred *before the period of ice*, and as the surface of the earth towards the north exhibits no appearance of special disturbance, it may be supposed that the aggregation of material took place while the substance of the globe was in a fluid state, when substance could more readily accord to some general law of aggregation.

The magnetic currents as exhibited in different manifestations, if to them could be attributed sufficient power, have a tendency to fulfil the various phenomena when examined with reference to *real* qualities presented under a name. The magnet indicates a power whose positive manifestation is toward the north called attraction, and whose negative is toward the south, which may be called repulsion. As has been before stated attraction is another name for contraction, or condensation, or weight, or cold; while repulsion is another name for expansion, or molecular motion, or heat and absence of weight. As a universally active and most powerful agent, such qualities would have a tendency to aggregate denser matter to its side of contraction, and to compose substances so aggregated sooner to a condition of rest. The phenomena attending its action would be increase of cold and weight at its north, with a tendency to increased heat, disturbance and lightness towards its south pole. All these conditions seem to be fulfilled save in the temperature of the northern and southern hemispheres;

that of the southern presenting a lower mean during the summer than that of the northern, while there may be as great a mean of cold south as north in the winter. But this may be said to arise from two extraordinary conditions; the effect of the sun's action and the different functions of water and land to receive and impart its heat. Yet while it is proper to state any apparently great objection to the theory, it may be said that the portions of the globe beyond the climatic influences of the surface, indicate by the increase of volcanic action toward the south corresponding increase of molecular disturbance and consequent development of heat.\*

A statement made by Humboldt with a foot-note may be read with interest, and perhaps may be thought to give strength to the view taken. "Terrestrial magnetism," he says, "and the electro-dynamical forces computed by the intellectual Ampère, stand in simultaneous and intimate connection with the terrestrial or polar light, as with the internal and external heat of our planet, whose magnetic poles may be considered as the poles of cold." \* \* \* "The remarkable connection between the curvature of the magnetic lines and that of my isothermal lines, was first detected by Sir David Brewster. This distinguished physicist admits two cold poles (poles of maximum cold) in the northern hemisphere, an American one near Cape Walker, 70° north latitude, 100° west longitude, and an Asiatic one, 73° north latitude, 80° east longitude. Whence arise, according to him, two hot and two cold meridians, *i.e.*, meridians of greatest heat and cold." When the idea that these peculiar features of the earth might be accounted for by the operation of a general law to which that of heat and gravity might be subordinated, the writer in seeking for the focus of volcanic action and its opposite of supposed greatest density to see if there was any apparent corroboration of the theory, had never had his attention called to this remark of Humboldt; nor was it until upon conversation as to a remarkable accordance of the grand features of the earth with the theory that his remarks were brought to light. The fact is stated to show how strongly the theory is supported by the coincidence of the Asiatic pole of cold of Brewster, with the apparent pole of greatest density sought by reference to the superficial distribution of land

\* See Note.

and water. Another curious circumstance having an important bearing on the subject is that the American pole of Brewster seems to be the pole of the ecliptic.

While nothing actual as a scientific deduction is claimed as the result of this train of thought, it certainly seems to serve the beautiful purpose of uniting numerous physical phenomena however antagonistic, under one general law, and points to this law as a grand controlling one.

The exact amount of the compression of the earth at its poles has never been ascertained, nor has it been ascertained that the compression of the two poles is the same. The difference of best settled results involves a difference in the earth's substance of a vast volume of matter. If the superficial aspect of the globe is as to matter a true indication of the location of its centre of density—supposing its shape to be that of a perfect oblate spheroid, or one of like curvatures from the equator to the poles—the centre point of its density would lie north and east, or on the Asiatic side of the centre of its mass. This being taken as true the centre of density would be carried toward that point by increasing the volume of the southern hemisphere by water sufficient to make up for its lack of specific gravity. It might well be objected to this that on such a supposition the increased mass being of water, its tendency would be to run down hill toward the equator to seek its level, and the simplicity of the proposition would prove its correctness. Now, it is a remarkable fact that in looking on the great charts of the ocean currents, (see Black's English Atlas,) considered as a whole, we will find the whole water surface of the globe from the south pole to say 70° south latitude, presenting the feature of a moving current of water *northward*, which before striking the continents is divided into various streams all tending north, until some are deflected east and west, and tending to the south in short curves are again brought to an east and west course, while others of great magnitude stretch away to the north pole as surface currents. This indicates the existence and even majestic exercise of enormous power which must be accounted for as springing from *underneath*, for the waters of the extreme south flowing northward are of cold temperature, and the phenomenon cannot then be accounted for to arise from sudden or irregular

heating of the water, nor from any other than a constant and apparently never varying power. It is believed to have been asserted that the waters of the western half of the southern hemisphere have a considerable degree of excess of height. This would indicate by increased volume of lighter matter the truth of what has been surmised, that by this increased volume the centre of density was drawn towards the point the centre of the sphere considered as a regular oblate spheroid, from the point indicated as that of its centre of density, when the different densities of earth and water were taken into consideration. As on our first supposition the centre of density of the earth lay to the north and east of the centre of the mass, the increase of water in the southern and western hemisphere would satisfy the condition of its being removed from the north and east to a point more south and west. The theory of a power possessing the combined property of attraction and repulsion, whose indications are to the north and south respectively, another name for which may be condensation and expansion, whose line of intensest force may be considered to be indicated by the poles of greatest and least density, and whose centre of greatest action may be esteemed to be the point of greatest density, if true would tend to account for this grand operation of ocean currents, by forcing the water from within outward towards the south, causing them to rise and flow over, the vacuum being supplied just as we see it in a boiling cauldron. And in fact we know that returning northern currents sink and are lost from the surface as they proceed southward. This movement would be attended by increased heat of the water,—as it has been already shown that the temperature of water is raised by simply the artificial disturbance of it,—independently of the vast amount of heat derived from the effect of the sun's rays when the surface is reached. This, if a theory that what is called magnetism is a great controlling power in a manner subordinating to itself so many apparently conflicting forces, is true, may be esteemed the most perfect and beautiful illustration of its operation, because we can realize and appreciate its practical working by the actual constant movement of an immense mass of matter.

The idea that magnetism or electricity exercises a great practical controlling power in our physical economy, and that one grand

feature attending such exercise is condensation or repose at the north, and expansion or action at the south, is further illustrated in the following letter from W. H. Weeks, addressed to the author of the "Vestiges," and by him appended to that work, as a note:—"On the 3d of October, 1842, I commenced an electro-chemical experiment which has constantly, since that period, been in progress, and will probably continue some time longer. It is not necessary to the present notice that I should detail the objects, etc. \* \* \* I shall, therefore, merely state that a cylindrical glass vessel, capable of containing about ten fluid ounces, with a bottom of porous baked earth, and open at the top, suspended in a convenient frame is about three-fourths filled with a solution of refined sugar in distilled water, receiving occasional supplies, and that the poles of a water battery of twenty pairs terminate within an inch of each other in the solution before mentioned, about an inch also from the bottom of the cylindrical vessel. Through the porous bottom alluded to, the saccharine liquid gradually percolated, during several months, that is, until its minute viaducts became completely obstructed. The solution thus filtered fell into a convenient glazed earthenware jar placed under the apparatus, and was occasionally returned to the inside of the glass cylinder.

"About the beginning of September, 1843, a small patch of fungus, of a peculiar character, was observed to have commenced forming on the outside of the glass near its lower rim, but yet not in contact with the line of junction between the glass and its earthen bottom. At this period the solution had ceased to drop through the earthen diaphragm, and the incipient fungus occupied a spot on the outside of the glass *directly opposite the negative electrode* within. This substance having, when first seen, a gelatinous appearance of a dark brown color, by slow degrees extended itself round the lower rim of the glass, forming an irregular band or zone, half an inch in breadth, and throwing out numerous protuberances as it approached the positive side of the arrangement. On the 29th of November, in the same year, the following note relative to this singular production occurs among my memoranda; and as I cannot better describe its mature appearance, I shall subjoin the extract. 'The substance

“ of this fungus varies in color from a light chocolate to that of a dark sanguineous red, and though formerly of a soft texture, it now offers considerable resistance. When viewed with an excellent pocket lens, a most singularly beautiful species of vegetation is seen to occupy its entire surface, presenting various shades of crimson, green, olive, and green inclining to yellow. In its general appearance it at once suggests the idea of a magnificent forest, consisting of trees and flowering shrubs in miniature. In particular spots, fine downy needle-like spires occur in vast multitudes, and these otherwise naked processes, rising from the body of the fungus, are surmounted by what appear to be seed vessels in some instances, and irregular feathery tufts in others.’

\* \* \* About the Autumn of the year 1844, the fungus had extended to the opposite side of the arrangement, thus forming a continuous circular band; and it is not the least remarkable feature of its brief history, that *immediately on the completion of this event* the luxuriance and beauty of its vegetation were observed rapidly to decline. \* \* \* The commencement of the fungus at a point precisely corresponding with the negative poles of the arrangement, its luxuriance and maturity in the intermediate space on the glass cylinder, and its decay on finally reaching the positive side, are in themselves facts pleading strongly in favor of electrical influence over the organization of this remarkable species of vegetation.” The words “immediately on the completion of this event,” have been italicised, as with the other words italicised by the author, pointing to the special features desired to be illustrated by the letter, of repose at the north and expansive action at the south, which phenomena although casually noticed by the author did not seem to have attracted his attention as bearing towards the object we have had in view. Another beautiful illustration of the action of magnetism upon a mass composed of two substances of differing densities is seen in the experiment of decomposing water, in which oxygen gas the denser substance seeks the north pole, while hydrogen gas the substance of least specific gravity seeks the south or negative pole of the battery; and the force of the illustration is added to when it is considered that the gases collect at the poles, simply because they are the points where the influence of attraction and

repulsion ceases, and that it is the force of attraction and repulsion not of the poles themselves or the material they are made of, which compels the particles of matter to motion.

Could it be demonstrated that the waters of the ocean are moved in the manner stated by a force of this kind, the inference would be inevitable that were the masses of the earth expanded to a condition in which obedience to such a law could be rendered, we would have a never-ceasing circular movement of them, from within out, relatively varied according to their specific gravities. If a condition could be conceived in which apparently greater effect would be produced by the repulsive property than the attractive, or one in which the two forces admitted, a different arrangement of the atoms of the great mass, the line of direction of the forces remaining the same, the result would produce from our earth a comet similar to those we now see describing such elongated ellipses in the heavens. And as the attractive force of the sun might be considered to remain the same as it is now, we would find that our earth in its new condition would at once present its northern pole or that of its greatest density to it, while its southern extremity or brush would always hold a position pointing most remotely from it; or, in other words, the major axis of the earth would always point directly to the sun's centre.\*

Again, imagining this to be the case, by supposing to produce a change in natural economy there was given a greater force to the power of attraction to produce a subsidence of the molecular action of the mass, or the antagonism of attraction and repulsion in and under one law to continue modified by a relatively greater power of contraction, the result would be, *first*: an aggregation of denser matter towards the pole of rest. *Second*: the congelation of such substances as required the highest measure of motion for the separation of their atoms, and, *third*: greater compactness of the entire mass, with an ever increasing approach to a perfect sphere: and with such an approximation the foci of the ellipse would approach each other, until a perfect sphere having been arrived at, the foci would become identical in space, and the path of the earth would become a circle. The fact that it is not a circle but an ellipse is almost a demonstration that a maximum of

\* See Note.

congelation or contraction had taken place at such a time, and had resulted in such a shape, that the face presented to the sun as the centre of attraction was neither polar nor equatorial, but rather that point in Asia before mentioned, as the nadir point or pole of the earth's density. As a mere conjecture founded on such simple facts as are herein stated, is it not remarkable that the point opposite to this in North America is the polar point of the ecliptic?

If the contraction was such as to make the polar diameter shorter than the equatorial, the position of the earth would change, relatively, to the sun, and instead of the pole being presented to it the plane of the equator would come upon the plane of the sun's centre, to which it now approximates. Were the earth a perfect spheroid, with the centre of density directly at the centre of the mass, the equatorial plane would coincide strictly with that of the sun's centre. The measure of its divergence from that plane must be the measure of the distance of the actual centre of density from that of the mass, or must be the measure of the irregularity of its conformation.

A change in the condition of the substance of the earth producing such changes in its motion and position relatively to the sun, judging from the analogy of all geological teachings, must have required ages, marking a line of constant progression. In the course of these ages there was a time when the northern hemisphere being presented steadily to the sun, without the alternation of the night season, must have had a climate entirely relieved, superficially, of ice. What that climate produced can be but matter of conjecture.

Thus pursuing a grand law possessing within itself the properties of attraction and repulsion, or condensation or contraction and expansion, or cold and heat, or weight and its absence, or darkness and light, with never-ceasing motion, to apparently legitimate results, we derive a beautiful resolution of forces regulating planetary motion, under one, a higher law, drawing all causes to itself as a primal one under an adorable Deity, in obedience to which the earth has assumed its present conformation, and by which volcanic action and the ocean currents are created.

A short time after the foregoing Essay was written, while engaged with a friend in investigating the causes of want of homogeneity in the mass of heavy ordnance, and seeking for a method of manufacture by which sameness of structure might be secured, the question came up as to the cause of congealed iron floating upon melted iron. The buoyancy of the one is increased proportionately to the degree of the heat of the liquid, and the degree of the coldness of its own mass. What is the cause?

In the ratio of its expansion the one has lost specific gravity, and for that reason a congealed mass of the same material should sink into it. In proportion as one loses specific gravity by its expansion, and the other gains in condensation by congelation, by that double proportion should the congealed mass sink in the liquid. The reverse is the case.

The liquid iron is in a condition to admit of obedience to its especial power of attraction to its own centre, and the congealed iron should sink to that centre, at the same time the attraction toward the earth's centre is drawing the cold iron to itself: wherefore there are two forces of attraction striving to draw the congealed into and through the liquid mass, agreeably to our experience that the heavier will sink in the lighter material.

As further conditions of the law of motion in the liquid mass we have also light and heat.

The attraction of gravitation being uniformly the same as to duration, here also, we have an illustration of the action of two laws of attraction and repulsion, and of obedience to both laws at the same time; but an obedience occasioned by such a preponderance of the law of repulsion as to bring about a condition of things contrary to our experience. That obedience is brought about by the action of two other laws—other in name, but the same in effect—motion and rest; motion in the liquid mass, and rest or comparative rest in the congealed.

Now, with this example before us, let us, standing upon the earth, look out toward the sun. In the magnificent splendor of its rays which our eyes behold, in the warmth of its beams, which become sensible to our touch, in the visible effects of both light and warmth, fructifying the earth in a thousand ways, shall we say that we have two living, visible and tangible indications of a law

of expansion and of repulsion, which holds our earth to its place as against that other law ever seeking to draw it towards a common centre—that other law which it equally embraces, and by which it is equally embraced?

Shall we further say that the two laws of gravity and of its opposite, are after all but properties of one and a higher law: that they are but properties of motion pervading more or less, all things according to their kind—that motion which is, as it were, life infused into an inert mass by the breath of the Lord God *our* Maker?

NOTE 1. The statement is manifestly erroneous, and its terms incorrect. It can only be said of it, that not dwelling upon it as of necessary consequence to the main object of the essay it was carelessly made, and escaped a careful examination until after the forms had been made up from the proof sheets. This is one reason why it is permitted to remain as it is. Another and stronger reason is that the essay was written under circumstances such that the writer is desirous to preserve it entirely in its original arrangement.

Starting with the facts that every position which the earth has in its orbit relatively to the sun, and that the condition of its velocity at any point, is to be determined accurately by the law of gravity, and that other fact that two forces are necessary to the completion of its revolution, a train of reasoning as to the operation of those forces may follow, leading one to doubt somewhat that the revolution of the earth is caused by the efficacy and exertion of those forces alone.

The velocity of the earth in its orbit is greatest at that point lying nearest to the sun, which must be  $A'$ , and the velocity is constantly accelerated in the path of travel  $A B A'$  to  $A'$ . The path  $A B A'$  exhibits a constant approach to the sun, which must approximate by constantly increasing ratio of velocity, provided the power of gravitation drawing it thither increases by a constantly increasing ratio, the power of repulsion being constant or decreasing by a constantly decreasing ratio. If the repulsive force be given at  $A$  as a uniform force, or one relatively to the power of gravity decreasing by a constantly decreasing ratio, the power of gravity preserving its integrity, resulting in the line  $A B A'$ , it is difficult to see why the path of the earth from  $A'$  would not be upon the continuation of the line  $A B A'$  closing upon its centre of attraction by an ever diminishing spiral. Considering the forces and their effects thus given, the path  $A' B' A$  would not be the natural one, but would ensue upon such a change of forces, as to give that of repulsion the predominance, the effect of the power of repulsion increasing and that of gravitation decreasing in such measure as to perfect the figure of the orbit. The figure being symmetrical, the sum of the two forces expended on the line  $A' B' A$  would be equal to that expended upon the line  $A B A'$ . Therefore the forces would correlate. Without, however, the change taking place at  $A'$ , all the force of increased velocity would be in the direction of the sun upon the continued spiral, and the force tending to carry the

earth in the path  $A' B' A$  would, in a sense, be at its weakest at  $A'$ , and in effect, the statement made would be good, though the terms of the statement are erroneous. Still it is also evident that by the change that must take place to convert one force into another, the force of repulsion, which at  $A'$  in the path of the ellipse is weakest in respect of the earth continuing in what might be called its natural path toward the sun, must nevertheless, as to continuing the path of the ellipse be strongest at the same point, that is at  $A'$ , because that is the point at which the force of greatest resistance is offered. Hence both forces, as to the perfecting the path of the ellipse, are strongest at  $A'$ , and weakest at  $A$ .

Suppose the sun to present no other obstacle to the passage of the earth in the direction  $A A'$  save the power of attraction which it possesses, and the earth to move in the direction  $A A'$ , would the velocity acquired by the power of gravity alone be sufficient to carry the earth to a distance in the direction  $E A'$ , equal to the distance  $A E$ ? In other words, does the power of gravitation generate a power of repulsion equal to itself?

Admitting that it does, it must be that the entire force of the power of gravitation is represented by the line  $A E$ , repeated as long as reciprocating motion should endure, which by the very terms would be to infinity. Applying this as a measure to the case of the path  $A B A'$  continuing as a closing spiral, however long the spiral might be, the force necessary to draw it eventually to its centre of attraction would likewise be represented by  $A E$ . As the forces to perfect the path of the ellipse correlate, that of gravity being represented by  $A E$  on like grounds, the force of repulsion in case of the path being that of the spiral would necessarily correlate with that represented by  $A E$ . The same may be said of the force necessary to produce the path of a circle.

Hence it would seem that the forces of attraction and repulsion necessary to complete the earth's revolution, though opposed to each other, yet necessarily so to speak, correlate and are identical as to time and place of exercise. If the two opposing forces correlate as shown, and are identical as to time and place of exercise, it is evident that a unit of measure of the symmetrical half of an ellipse would be the measure of the other and the elements of the force of gravity being found accurately to apply to the velocity and position of the earth in one of such halves would necessarily apply as accurately for the other, although the preponderating force was of an exactly opposite character.

From what has been said, if true, either of the three paths might be pursued, spiral ending in the centre of attraction, or that of a circle, or that of an ellipse, by the exercise of the same force. But of the three, whichever might be the one found to exist, that one would depend upon other causes than the elements of the forces common to all for its existence. Therefore, the reason why the orbit of the earth is not an ever lessening spiral rather than an ellipse cannot be derived from the elements of the forces satisfying the condition of either, for those forces are common and convertible from reciprocating into circular movements.

But again, as to an ellipse, if it is true that the two opposing forces are relatively strongest and weakest at  $A'$  and  $A$ , and consequently that they are simultaneously of equal strength at any point, it would seem that they balance or neutralize each other at any point. This view pursued would involve the necessity of the introduction of new forces, which, in their turn, without further as-

sistance would not be found to answer, so that we find ourselves constantly at like kinds of unsatisfied conditions with those who strive for means of perfecting perpetual motion.

The more carefully one considers these matters, the more convinced he becomes that *intelligence* and *will* must be added to the possession of these forces to make them effect the ends we see perfected. Whether it be of a subordinate character as of a creature, or whether it be a direct emanation from Deity, who can tell? Whether or not these very worlds, which we are pleased to speak of as inanimate, senseless and material things, are endowed with life, intelligence, and will in measures commensurate with their excess of size beyond ours, who shall say?

NOTE 2. "But the most remarkable feature presented in the lunar surface, is "the tremendous depths of some of the cavities, and their immense magnitudes. "Some of them extend beneath the general level of the country to a depth of 10 "to 17,000 feet, and their rough misshapen, precipitous sides exhibit scenes of "rugged sublimity to which earth presents no parallel. Of these cup-shaped "cavities, *especially in the southern portion of the lunar hemisphere*, the number is "beyond credibility."—*Mitchell's Popular Astronomy*, page 94.

May it not be possible, could we see the opposite and southern side of the moon, that it with that seen, would present much the same spectacle with our earth divested of its water envelope; exhibiting only more marked features of the law of comparative rest at the north and disturbed action at the south? Features more marked, because our satellite is said to have no water nor atmosphere to cover, in a measure, and gradually obliterate the marks of the terrible primeval disturbances.

NOTE 3. "The *envelopes* of comets and their *tails*, are by far the most inscrutable problems of nature. Of these phenomena no satisfactory account has yet "been rendered. The envelopes of the comet of 1858 were beautiful in form, "with a well defined circular outline, in whose center the nucleus blazed with "its fiery light. The diameter of this seemingly globular mass changed from "night to night. Its texture varied; sometimes evenly and beautifully shaded, "and gauze like in its surface, and sometimes this gauzy surface broken by dark "and irregular patches. A second concentric sphere became visible, fainter in "its outline than the interior one, and finally a third circle dimly presented its "outline, very faint and only to be seen in powerful telescopes, under favorable "circumstances."

"The beautiful forms exhibited in these envelopes and retained by them seems "to demonstrate the existence of some *central repulsive force* located in the nucleus "and capable of holding these gaseous particles in equilibrium. What this "force may be it is vain to conjecture. If the envelope of the nucleus is a phenomenon surpassing the reach of human thought, what shall we say of the still "more mysterious and incomprehensible phenomenon presented in the tails of "comets?" *Mitchell's Popular Astronomy* page 293.

Do not these envelopes indicate substances of differing densities not yet contracted to a solid or liquid form—moved by that repulsive force claimed in the Essay?